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A System for the Feedback of Experience from Events in Nuclear Installations

DRAFT SAFETY GUIDE

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Draft Safety Guide to supersede IAEA Safety Guide on Systems for Reporting Unusual Events in Nuclear Power Plants (Safety Series No. 93, Part 1)

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1. INTRODUCTION

BACKGROUND

1.1. Operating experience is a valuable source of information for learning about and improving the safety and reliability of nuclear installations[1]. It is essential to collect information in a systematic way, that meets agreed thresholds for reporting on events occurring at installations during commissioning, operation, surveillance and maintenance activities, decommissioning and on deviations from normal performance by systems and personnel which could be precursors of events.

1.2. In 1989 the IAEA published a Safety Guide on A System for Reporting Unusual Events in Nuclear Power Plants (Safety Series No. 93). The Safety Guide contained a recommended scheme based on national practice available and applicable to the management of safety related operational experience in nuclear power plants. The Safety Guide consisted of two parts: Part, I A National System and Part II, IAEA Incident Reporting System (IRS). Developed originally by the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) in the early 1980's, the IRS is, as of 1998 a single system jointly operated by the IAEA and OECD-NEA. The joint IAEA/OECD-NEA IRS Guidelines have been published [1]; they supersede Part II of Safety Series No. 93.

1.3. The IAEA safety standards series publications Safety of Nuclear Power Plants: Operation [2] and Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [3] set out safety requirements for the feedback of operating experience. The Nuclear Safety Convention, which entered into force in July 1996, recognizes fully the importance of the feedback of operational experience (operational experience feedback — OEF) as a tool of high importance for the safety of the operation of a nuclear power plant and its further enhancement in its Article 19.

1.4. This Safety Guide provides recommendations and guidance on satisfying these requirements and constitutes an update and an extension of Part I, A National System, of the Safety Guide, A System for Reporting Unusual Events in Nuclear Power Plants (IAEA Safety Series No. 93)[1].

[1] Nuclear Installation: a nuclear fuel fabrication plant, nuclear reactor (including sub-critical and critical assemblies, research reactor, nuclear power plant, spent fuel storage facility, enrichment plant or reprocessing facility.

OBJECTIVE

1.5. The purpose of this Safety Guide is to provide guidance for the establishment of an operational experience feedback system to manage operational experience on a national basis. It brings together common elements which typically constitute an effective system at the national level. It should be noted that the process of feedback of operational experience is undertaken by many different organizations throughout the world (licensees, regulators, designers, international organizations), which, by co-operating, ensure that the total process is efficient and effective. The Safety Guide identifies the various organizations within a State, their roles, responsibilities, and the timing of their involvement in the entire process.

SCOPE

1.6. This Safety Guide provides recommendations on all the main components of operational experience feedback systems, utilizing relevant event information and abnormal conditions that have occurred at nuclear installations throughout the world. This guide focuses on the interaction between the different systems for using operational experience feedback. The publication provides guidance for all of the organizations which are professionally involved in the nuclear industry, such as: regulatory authorities, technical support organizations, operating organizations with planned or ongoing nuclear programmes, vendor companies (designers, engineering contractors, manufacturers, etc.), research establishments and technical universities that work in the nuclear field.

1.7. Operational experience feedback systems are based on systems of plant operators. Related guidance is for example in The Operating Organization for Nuclear Power Plants Safety Guide, NS-G-2.4. Such systems make use of experience from recurrent testing and maintenance of safety related equipment, development of plant specific reliability data, plant specific indicators of system or human performance.

1.8 This Safety Guide does not deal with the special reporting procedures covered by the Convention on Early Notification of Nuclear Accidents or those which may be required under emergency conditions or covered by the International Nuclear Event Scale (INES) [4].

1.9. This Safety Guide is not intended to cover communications subsequent to an event that relate decisions concerning the operation of a plant that has been affected by an accident.

STRUCTURE

1.10. Section 2 of this Safety Guide covers the need for a national system of experience feedback. Sections 3 to 10 address the operational experience feedback process that should be established, covering: Screening of Events (Section 3), Investigation and Analysis (Section 4), Corrective Actions (Section 5), Trending and Review (Section 6), Utilization and Dissemination of Information (Section 7), Reviewing Effectiveness (Section 8) and Quality Assurance (Section 9) and Reporting of Safety Related Events (Section 10). Additional detailed guidance is provided in Appendices I through IV. Additional information is given in the Annex.

2. NEED FOR AND MAIN ELEMENTS OF A NATIONAL SYSTEM FOR THE FEEDBACK OF OPERATIONAL EXPERIENCE

GENERAL

2.1. The IAEA Safety Standards Series publication NS-R-2 on Safety of Nuclear Power Plants: Operation [2] sets out in Section 2 the requirements for establishing an operational experience feedback system to report, investigate, evaluate, trend, correct, utilize and disseminate information in relation to abnormal events occurring at nuclear power plants to the relevant governmental bodies, national and international organizations, and to the public. In addition, the IAEA Safety Standards Series publication GS-R-1 on Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [3] sets out the authority of the regulatory body to make available, to other governmental bodies, national and international organizations, and to the public, information on incidents and abnormal occurrences, and the regulatory body's responsibility to establish national regulations in the field of operating experience feedback, to ensure that operating experience is appropriately analysed, that lessons to be learned are disseminated and that appropriate records relating to the safety of facilities and activities are retained and are retrievable.

2.2. The Nuclear Safety Convention, which entered into force in July 1996, recognizes fully the importance of operational experience feedback (OEF) as a tool of high importance for the safety of the operation of nuclear power plants and its further enhancement. Article 19 of the Convention concerning Operation (Para vii) requires that "…each contracting party shall take the appropriate steps to ensure that: incidents significant to safety are reported by the holder of the relevant licence to the regulatory body; programmes to collect and analyse operating

experience are established, results obtained and the conclusions drawn upon, and mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies."

IMPORTANCE FOR SAFETY OF LEARNING FROM THE FEEDBACK OF OPERATIONAL EXPERIENCE

2.3. One general technical criterion of safety for nuclear installations is that the organizations concerned ensure that operational experience and the results of research relevant to safety are exchanged, reviewed and analysed and that lessons are learned and acted on. The primary objective of an OEF system is that no safety related event remains undetected and that corrections are made to prevent the recurrence of safety related events by improving the design and/or the operation of the installation. This criterion reflects the notion that an accident of any severity would most probably have been marked by precursor events, and to this extent would have been predictable and, therefore, avoidable. Feedback of experience also increases knowledge of the operating characteristics of equipment and performance trends, and provides data for quantitative and qualitative safety analysis.

2.4. Event investigating and reporting contributes to improvements in nuclear safety and has the following objectives:

- to identify and quantify events and conditions that are precursors to significant degradation and have the potential to cause accidents that can lead to plant damage or radioactive releases;
- to identify events that are important to safety and their associated safety concerns and root causes, and to determine the adequacy of corrective actions taken to address the safety concerns;
- to discover emerging trends or patterns of potential safety significance;
- to assess what could have happened;
- to assess the generic applicability of events;
- to prevent recurrence of similar events.

2.5. The organization which operates a nuclear installation should maintain an effective

system for collection and analysis of operational experience and should disseminate safety significant information promptly among its own staff and to other relevant organizations. The causes of all safety significant events should be determined and analysed. Events that may be regarded as precursors of accidents should also be identified and actions should be taken to prevent any recurrence. Each organization should learn from the experience of other organizations. The sharing of operating data should be co-ordinated nationally and internationally. In identifying important precursors, Accident Sequence Precursor (ASP) Studies (also named PSA Event Analysis) are useful. Further information on ASP studies is contained in Annex A-12 to A-16.

2.6. Plants are designed to be safe. A systematic analysis of many potential failure sequences under the assumption of certain criteria (e.g. single failure criterion) has lead to the currently high safety level. In order to address the possibility of a potential failure of any of the plant safety features, the concept of defence in depth [5] has been applied to the plant design. Owing to a well engineered design and the application of the defence in depth concept, most of the events occurring in nuclear installations do not have major consequences.

2.7. Events are indicators of a weakness in, or failure of one or more of the defence in depth barriers. A complete and systematic detection of failures in barriers is impossible. In many cases events may also indicate lack of adequate supervision or deficiencies in the safety management of the nuclear installation. From this point of view an event[2]. has to be taken as an opportunity for learning. Comprehensiveness and trustworthiness of event information provided to the regulatory body is an indicator of the installation safety culture.

MAIN ELEMENTS OF A NATIONAL SYSTEM

2.8 Although the national systems vary from State to State, an effective system for the operational safety experience feedback covers the following:

– reporting of events from plants;

– screening of events - primarily based on safety significance;

[2] As used in this Safety Guide, an event may represent either a plant transient with accompanying failures or anomalous performance, or it may refer to a condition or discovery of shortfalls in the plant safety systems, without an actual initiating transient. However, it is vital to maintain the distinction between a low level event (with no consequences) as contrasted with a reportable condition, which may have high-risk significance even though it has no immediate consequences.

- investigation of events;
- in-depth analysis of safety significant events, including causal analysis;
- recommended actions resulting from the assessment, including their approval, implementation, tracking and evaluation;
- wider consideration of trends;
- dissemination and exchange of information including international systems;
- continuous monitoring and improvement of programmes for operational safety experience feedback;
- storage, retrieval and documentation system for events.

2.9. The above elements generally describe the important components that need to be considered in the development and implementation of a national OEF programme. Annex 2 presents an example of the main elements of an operating experience feedback system. There should be a commitment from the management in the various participating organizations involved in the national OEF programme to ensure that it is efficient and effective.

2.10. A system utilizing feedback of operating experience is a two-way process, i.e. giving and receiving experience. Internal operating experience refers to the process whereby a specific nuclear installation learns from its own experience – including sharing that experience with others, whilst external operating experience refers to the receiving of information from another nuclear installation which may lead to the development of corrective or preventive actions to avoid recurrence of an event.

INVOLVEMENT OF THE REGULATORY BODY, OPERATING ORGANIZATION AND OTHER ORGANIZATIONS

2.11. Information on events, anomalies, situations or conditions starts at the plant level and should be communicated within the operating organization and then, in accordance with the requirements, to the regulator, other operating organizations, research organizations, designers, contractors and other relevant parties. As a minimum, if event information contains lessons to be learned for other States, it should be sent to the international bodies (the IAEA/NEA or WANO/INPO reporting systems) or to both for distribution. Therefore, the

flow of information on operational experience can run its full course from one State to another via the international co-ordinating agencies. At each step in the process of the dissemination of information, a number of the aforementioned elements (paragraph 2.8) should be involved. Screening and analysis are two important elements in the flow of information.

2.12. A detailed procedure should be developed by the operating organization based on the requirements for a national system established by the regulatory body. This procedure should define the process for dealing with all internal and external information on events in nuclear installations. The procedure should precisely define the structure of the OEF system, the types of information, channels of communication, responsibilities of the groups and organizations involved and the purpose of the documentation produced. Organizations that have various roles within the national OEF process usually include: operating organizations, the regulatory body, plant designers, and research organizations. The procedure should be available for review or approval by the regulatory body.

LINKS BETWEEN NATIONAL AND INTERNATIONAL REPORTING SYSTEMS

2.13. The effectiveness of the national OEF systems can be significantly strengthened by linking with international systems. Links between national and international OEF systems broaden the sources of information on safety significant events, the related lessons learned, and corrective actions taken at the plant or national level. Participants in such international systems can mutually benefit by sharing experience, reducing the risk of duplication and optimizing the use of resources to run the programmes in the OEF domain.

2.14. Participation in international OEF systems necessitates the establishment and harmonization of relevant parts of national OEF systems. National OEF systems should have procedures in place to deal with international information, from the moment they are received until the time that they are disseminated. The standard format and contents of IRS reports [1] may be considered for adoption in national OEF systems, in order to more efficiently link national and international systems.

2.15. In view of the number of events likely to be of interest and the resources needed to evaluate them, some form of ranking should be considered.

2.16. Reports initially screened for applicability by a nuclear installation should also be screened at the regulatory level. This screening should consist of evaluating the specific

applicability and the possible effects on the nuclear installation, and of estimating the potential for the event to occur at the nuclear installation.

2.17. In order for one State to benefit from the operational safety experience gained in other States with nuclear power programmes, the IAEA and the OECD-NEA operate jointly an international system for exchanging information on safety related events that have occurred in nuclear installations. The international Incident Reporting System (IRS) is established as an efficient system to exchange important lessons learned from operational experience gained in nuclear installations of the IAEA and NEA States. The IRS is based on the voluntary commitments of the participating States and is reliant on national reporting systems that together enable an international perspective. The IRS provides information for regulators and their technical support organizations, as it provides insights on important international operational experience, for oversight and licensing purposes.

2.18. Operating organizations also have their own event reporting system, the World Association of Nuclear Operators (WANO) reporting system. The WANO operational experience programme provides a forum for utilities operating commercial nuclear installations worldwide to exchange event information for both nuclear safety and plant reliability purposes. The criteria for reporting events to WANO, whilst similar to those of the IRS, are directed towards the needs of operating organizations. Therefore, it is possible that the WANO event database will contain a different cross-section of events than that of the IRS.

2.19. In order to minimize duplication for operating organizations and to ensure common understanding of particular themes in terms of data analysis, IAEA/NEA and WANO have undertaken to co-operate in certain areas. These include the coding structure for the IRS database and the WANO events database as well as the common areas of operational experience guidelines and event investigation tools.

3. SCREENING OF EVENTS

PURPOSE OF SCREENING

3.1. Screening of event information is undertaken to ensure that all significant safety relevant matters are considered and that all applicable lessons learned are taken into account. The screening process should select events for further detailed investigation and analysis. This should include prioritization according to safety significance and recognition of adverse

trends.

3.2 The quality of screening depends, in part, on engineering judgement. Therefore, highly experienced and knowledgeable personnel should be assigned to this task. Many of the basic causes of events contain an element of human factors. It follows therefore, that selected OEF emanating from events arising in the plant or at other plants, should be scrutinized by personnel not only from the engineering and scientific perspective, but also by those with knowledge of human performance and behaviour.

3.3 All organizations involved in the OEF process should screen information on events bearing in mind their own needs. Operating organizations should have the objective of improving safety, plant availability and commercial performance by identifying the causes of events and thereby avoiding their recurrence and by evaluating the applicability of good practices used by others. Regulatory bodies should review the screening of events to gain insights that can be used to inform their inspection programme, licensing activities, elaboration of regulations and requirements for safety backfits. Regulators should screen national reports for their international use. Vendor companies should use the OEF data to improve their design and manufacture of structures, systems and components. Similarly, research establishments may use the OEF data in support of their research goals and programmes.

3.4 One element of the screening process that is carried out centrally or at plant level should be to consider the applicability of corrective actions taken by other plants in response to an event investigation.

SCREENING AT THE PLANT LEVEL

3.5 At the nuclear installation, two sources of information are available: internal and external operational experience. Internal events are those that occur at the plant. External information is the experience coming from outside, either from the same State or another, in nuclear installations featuring either similar or different technologies.

3.6 The screening of internal events should be carried out promptly to rank the priorities in the event feedback process and in the follow-up actions. The screening of internal events should be performed first by appropriate personnel to determine if there is any immediate implication for the plant. The event should then be screened by a suitable multidisciplinary

group of plant personnel against specified criteria to determine if the event needs to be notified to the regulatory body or utility representatives. This group should regularly review every event occurring at the plant and discuss whether the causes have been clearly identified, whether the corrective actions have been taken or planned and the corrective actions have been commensurate with the causes. The events screened out and found initially to be of less safety significance should be considered for trend analysis. The results of screening may be reviewed during subsequent periodic self-assessment or peer reviews. The history of the screening process should be made available to the regulatory body.

3.7 Use of external operating experience can have the benefit of uncovering latent failures which could pose a safety concerns. The information should first be reviewed to determine whether it is applicable for the plant; this should include consideration of aspects such as:

– generic implications which apply to the plant;

– similar equipment at the plant;

– similar practices that predispose the plant to similar events;

– the prior occurrence of a similar event;

– reported actions which are applicable to the plant.

3.8 Screening of external events at the plant level should be undertaken periodically. The screening criteria for external events should follow the criteria that govern internal event reporting to determine whether detailed investigation is necessary. Those inputs considered applicable should be distributed to the specific branches (e.g. radiological protection, operations, maintenance) for analysis, assessment and consideration of applicability or for information. Results of the screening at the plant level should be recorded for evaluation during subsequent periodic self-assessment or peer review. The history of the external event screening process should be made available to the regulatory body if so required.

3.9 Information on operational experience found to warrant further investigation should be considered in sufficient detail to arrive at a thorough understanding of the event. This often implies getting additional information primarily from the plant at which the event occurred, but also from other organizations (e.g. other plant of the same type, utility headquarters, international organizations) if necessary. After completing this step, a decision should be

made on whether the information needs analysis in depth.

SCREENING AT THE NATIONAL LEVEL

3.10 In States with a nuclear industry in several locations, additional screening by the following organizations is recommended:

(a) a centralized group to provide leadership for the OEF process, including safety assessment and cause analysis issues; (this may be a joint undertaking involving several utilities);

(b) vendors, suppliers and designers, who use operational experience to improve designs;

(c) research institutions.

3.11. The regulatory body should not only conduct screening of incoming event information but should also inspect the nuclear installation's screening process in order to ensure that the screening is effective in identifying events for analysis. The regulatory body should also have a strategic role and should monitor the OEF process to ensure that it is effectively conducted by the operating organizations.

4. INVESTIGATION AND ANALYSIS OF EVENTS

INVESTIGATION OF EVENTS

4.1. The IAEA Requirements for Operation [2] state in Section 2.21 that "Operating experience at the plant shall be evaluated in a systematic way. Abnormal events with significant safety implications shall be investigated to establish direct and root causes. The investigation shall, where appropriate, result in clear recommendations to the management of the nuclear installation, which shall take appropriate corrective action without undue delay. Information resulting from such evaluations and investigations shall be fed back to the plant personnel."

PURPOSE AND GENERAL CONCEPTS

4.2. Accordingly, the operating organization/licensee should have procedures specifying the type of investigation that is appropriate for any particular type of event. Such procedures

typically outline the conduct of an investigation in terms of initiation, duration, composition of the investigation team, format of final report and terms of reference for the investigation team. A typical outline for an investigation process is given in Appendix III.

4.3. The consequence of an event and the frequency of recurring events shall influence the level of investigation carried out. Significant events that would influence the magnitude of an investigation may include the following characteristics:

- consequences of the event and extent of damage to; structures/equipment/component;
- injury to on-site personnel;
- a similar occurrence has taken place earlier in the same installation or similar type of installation;
- a significant radiological release or personnel overexposure;
- plant operation that exceeded OLC, or was not included in, the design basis of the nuclear power plant;
- a pattern which is sufficiently complex, unique, or not well enough understood.

4.4. The scope of event investigations should appropriately vary i.e.:

- in the case of a serious single event, a Panel or Board of Inquiry involving many people, making extensive use of root cause analysis techniques and chaired by a very senior officer;

and for

- a non-consequential or minor event, or adverse trends, a relatively quick and simple investigation conducted by an individual trained in event investigation techniques. This latter type of investigation may only result in identification of an apparent cause (rather than a true root cause).

4.5. Paragraph 5.16 of GS-R-1 (ref. [3]), states *the regulatory body shall carry out inspections at short notice if an abnormal occurrence warrants immediate investigation.*

ANALYSIS OF EVENTS

4.6. The IAEA Legal and Governmental Infrastructure Requirements [3] states in Section 3.3 (7) that "…the regulatory body shall ensure that operating experience is appropriately analysed and that lessons to be learned are disseminated".

4.7. Event analysis should be conducted on a timescale consistent with the safety significance of the event. The main phases of event analysis can be summarized as follows:

– establishment of the complete event sequence (what happened);

– determination of the deviations (how it happened);

– cause analysis;

  - direct cause (why it happened);
  - root cause (why it was not prevented);

– assessment of safety significance(what could have happened);

– identification of corrective actions.

4.8. At the plant level as well as at the regulatory body level, several follow-up activities should occur after an event analysis. These activities comprise the documentation and storage of the analysis of the event, the dissemination of significant results, the monitoring of the implementation of the corrective actions and the assessment of their effectiveness.

4.9. It should be noted that the designation of safety significance can be changed during the analysis of the event. The regulatory body should be kept informed of any such changes so that it can fulfill its duties and responsibilities, e.g. making information available on incidents (section 2.6 (12) of Ref. [3]).

4.10. The analysis of any event should be performed by an appropriate method. It is common practice that organizations regularly involved in the evaluation process use standard methods to achieve a consistent approach for the assessment of all events. These standard methods normally make use of different techniques. Each technique may have its particular advantages for cause analysis depending on the type of failure or error. Therefore, it is not possible to recommend any single technique. The use of one or a combination of techniques in event

analysis should ensure the identification of the relevant causes and contributing factors which aid in developing effective corrective actions (further details on event analysis methodologies are provided in Appendix IV and reference [9]).

5. CORRECTIVE ACTIONS

GENERAL

5.1. Actions taken in response to events constitute the main objective of the OEF process to enhance safety at nuclear installations. They are aimed generally at correcting a situation, preventing recurrence or enhancing safety. The safety significance of the event, which includes its potential consequences, determines the depth of the cause analysis needed and subsequently, determines the type and the time limit for implementation of corrective actions.

5.2. The development of recommended corrective actions following an event investigation should be directed towards the root causes and the contributory causes and aimed at strengthening the weak or broken barriers that failed to prevent the event. The operating organization and its personnel are responsible for implementing corrective actions promptly and effectively. A sense of personal interest or ‘ownership’ should be promoted by involving the members of the organization’s event investigation team in formulating the corrective actions to be recommended.

TYPES AND AREAS OF CORRECTIVE ACTIONS

5.3. Recommendations on corrective actions should be proposed on the basis of either internal or external feedback information and should be identified prior to, or as a result of a thorough analysis of an event. Corrective actions should be developed by the affected plant. However, in some cases, such as for generic safety issues, the development of the corrective actions should involve other relevant organizations and depending on the national structure, may involve the regulatory body. Recommended actions should aim at improving human performance, equipment, or managed processes, as for example:

– modifications to equipment, installation of additional devices and means to prevent recurrence of the same or similar events;

– improvements of procedures and administrative means, additional checks and control;

– resolving deficiencies revealed in operating documentation (operation manuals);

– resolving deficiencies in normative documents;

– training of personnel to perform jobs properly;

– changes to the work environment;

– changes to the planning and scheduling of work and/or to the individuals assigned to particular duties.

5.4. In addition to their suitability for the affected nuclear installation, corrective actions may also be applicable to other operating plants, plants under construction or future plant designs, operating limits and conditions (OLC), improvement of procedures and training of personnel. The corrective actions may also have implications for other operating organizations and regulatory bodies. Where a corrective action is screened and found to be relevant it should be included in the plant's own corrective action plan.

5.5. A number of important factors should be taken into account when determining corrective actions. These should include the need:

– to restore or maintain the desired level of nuclear safety;

– to address human and organizational factors;

– to consider the overall impact of the action on existing documentation and operational aspects.

5.6 However, generating too many actions may overwhelm the intended beneficiary and leave some important ones outstanding for too long. It is desirable therefore, to prioritize corrective actions. Those actions affecting safety must be given the highest priority whilst the actions that are desirable rather than essential should be shown as such. Corrective actions can be either immediate, interim or long term with a need for detailed evaluation. Examples of immediate actions are measures to recover from a plant transient or to isolate contaminated areas. A specific procedure should exist to ensure appropriate control measures are carried out (See Appendix IV).

5.7. A tracking process should be implemented to ensure that all approved corrective actions are completed in a timely manner, and that those actions with long lead time to completion remain valid at the time of their implementation in the light of later experience or more recent discoveries. A periodic evaluation should be carried out to review constantly the need for items in the outstanding corrective actions list and separately to check the effectiveness of actions implemented. Primarily, the implementation and tracking of corrective actions should be performed by the plant management. The regulatory body may monitor the progress of certain recommended actions. This may be done by requiring plants/operating organizations to provide periodic progress reports.

5.8. In addition to the documentation and tracking of actions associated with each single event, a systematic compilation of actions should be made in order to provide an historical information base of lessons learned. When these actions are compiled and sorted on the basis of the systems affected or safety issues raised, they can then serve as solutions for similar problems which could arise in the future, or at other plants.

6. TRENDING AND REVIEW TO RECOGNIZE EMERGENT PROBLEMS

6.1. The IAEA Requirements for Operation [2] states in paragraph 2.23 that "…operating experience shall be carefully examined by designated competent persons for any precursors of conditions adverse to safety, so that any necessary corrective action can be taken before serious conditions arise".

6.2. Trending is a process used to identify degrading conditions based on the analysis of past plant events (precursors). Plants will trend event causal factors derived from apparent and/or root cause analysis. The goal of any trending programme should be to identify an abnormal trend early enough so that the operating organization can initiate an investigation and establish corrective actions to prevent a significant event. Corrective actions that address identified weaknesses should be specified and implemented through the corrective action programme. Industry experience indicates that trending of event information in this manner makes full use of investigation information and can provide useful indications of the inherent safety culture for line managers.

PURPOSE OF TRENDING INFORMATION FROM OEF

6.3. The purpose of an event trending process should be to find the frequency of the occurrence of certain data that have been gathered from minor and major problem reports and event investigations. These data include information about failed equipment and shortfalls in human performance, as well as situational data that describe conditions at the time of the events.

6.4. Data from programmes, other than problem/deficiency reports, should also be trended to obtain a broader perspective of plant strengths and weaknesses. For example, trending information from industrial safety reports, radiological contamination reports, and maintenance work records can provide useful insights.

6.5. Trending should be used to analyse the performance of various work groups, to identify those factors that either result in less-than-desired or better-than-expected performance. Follow-up investigation should be performed to better understand why an abnormal trend is occurring, in order to determine the causal and contributing factors.

6.6. A coding system should be applied that enables events to be characterized. Selected parameters or groups of parameters can then be trended to identify recurring themes, e.g. plant system, work group, activity cause etc. Examination of these parameters can enable the identification of adverse trends and the potential for recurring events.

6.7. Types of trending that provide useful information are those that identify:

– recurring data from coded events, preferably after detailed investigation;

– abnormal trends relating to plant work groups;

– abnormal trends during certain operating modes and activities;

– recurring system and component failures;

– the difference between trends during an outage compared with trends during non-outage periods;

– those work groups that are performing well;

– doses for different activities, as an input to ensure exposures to ionizing radiation are

ALARA.

METHODS FOR DETERMINING ADVERSE TRENDS

6.8. As trending is performed to identify a deviation from an anticipated level, a method to recognize the deviation is necessary. Generally, a comparison should be made between the frequency with which a parameter occurs over time and a threshold value that should incorporate the anticipated values. Any deviation beyond the threshold value should be considered for further analysis.

INVESTIGATION OF IDENTIFIED ABNORMAL TRENDS

6.9. Personnel at nuclear installations should have arrangements to routinely identify adverse trends from event analysis data so that follow-up investigation might be undertaken. Coding of data makes this task easier.

6.10. Once an abnormal trend has been identified, it should be treated as an event, and the established deficiency-reporting programme should be used to initiate an appropriate analysis and determine whether the trend is identifying adverse performance. The level of the analysis should be based on the significance of the trend and the potential consequences. A thorough root cause investigation can identify causal and contributing factors that explain why a trend is occurring. Corrective actions should focus on addressing the causes and be incorporated into the organization's corrective action process or programme. Subsequent follow-up should be conducted to verify that the adverse trend has been corrected, or to modify the original corrective actions.

6.11. The investigation should then focus on these more frequent factors, thereby increasing the probability that the actual (root) cause(s) of the adverse trend will be identified[3].

REPORTING THE RESULTS OF TREND ANALYSIS

6.12. Trend analysis reports should:

– provide useful information to line managers at a regular frequency depending on the amount of coded event data generated;

[3] This point is important because the majority of the causal factor data are obtained from apparent cause analyses. Since apparent cause analysis is not rigorous, it follows that more in-depth investigation is necessary to obtain additional detail regarding causal factors for events.

– focus attention on those items in the trend report for which further action may be necessary;

– provide sufficient detail in the report so that adverse trends can be understood;

– clearly label trend report graphs;

– present data in a format that is easy to reference (e.g. tables).

6.13. When reporting trend data, only information that is both useful and necessary should be provided. The primary goal of trending is to provide an "early warning" to operating organization management of abnormal trends and to help understand the factors that may be responsible. A group of people within the operating organization/licensee should be brought together to review and examine trends and patterns on a routine basis (e.g. every three months). Line managers are ultimately responsible for deploying the resources necessary to identify the causes of adverse trends and implementing necessary corrective action.

7. UTILIZATION, DISSEMINATION AND EXCHANGE OF OPERATING EXPERIENCE INFORMATION

7.1. The IAEA Requirements for Operation [2] in paragraph 2.22 identifies that the operating organization "…shall obtain and evaluate information on operating experience at other plants to derive lessons for its own operations…" and in paragraph 2.25 that the plant management "…shall maintain liaison as appropriate with the organizations (manufacturer, research organization, designer) involved in the design, with the aims of feeding back information on operating experience and obtaining advice, if necessary, in the event of equipment failures or abnormal events".

UTILIZATION OF OPERATING EXPERIENCE

7.2. Managers of nuclear installations should clearly define their expectations regarding the systematic reporting, screening and use of internal and external operating experience. Operating experience information should be made readily accessible to plant personnel. For example, licensees should issue information relating to operating experience when assigning plant work (e.g. in the form of a resume of past events, team briefings, toolbox talks, so-called Just-In-Time (JIT) information about events that have occurred elsewhere under similar plant conditions and lessons learned). In this way personnel are reminded of previous problems

locally, and at other locations relevant to the plant on which they are about to work. Effective use of OEF should be actively encouraged and reinforced by plant managers and supervisors, including the use of operating experience in refresher training for plant personnel.

DISSEMINATION AND EXCHANGE OF INFORMATION

7.3. The objective of disseminating information on events is to facilitate the following:

- For operating organizations/licensees to be able to improve the safety of the plant by implementing the applicable corrective actions derived from operational experience;
- To improve the understanding by the operating personnel of the operating conditions and plant response characteristics;
- To enable the vendors to be able to improve their design and manufactured products by incorporating lessons learned;
- To enable contractors providing maintenance services to be better prepared to anticipate potential problems;
- To enable research establishments to prioritize research and provide an additional means of improving their knowledge which may be of help to the nuclear installation.

7.4. For maximum impact and benefit, appropriate information relating to OEF should be disseminated to relevant bodies. This should occur at appropriate levels e.g. plant, operating organization, national, and international. A list of possible recipients for different types of information may include: regulatory authorities, organizations with planned or ongoing nuclear programmes, technical support organizations in the nuclear field, vendor companies (design firms, engineering contractors, manufacturers, etc.), research establishments and universities working in the nuclear field.

7.5 Dissemination of information involves a number of organizations, such as the regulatory body or operating organization, and should include the centralized arrangements set up by IAEA and OECD-NEA and by WANO, though other arrangements that fulfill the same objectives may be adopted.

7.6 By actively participating in the dissemination and information exchange programmes, the originator should also benefit from the increased opportunity for receiving feedback from other organizations and service providers. In this way dissemination will lead to a more broadly based effort to improve safety by using operational experience from nuclear installations and other related industries. It may contribute to the effectiveness of decision-making at the affected organization and enhance regulator confidence in the safe operation of plant.

7.7 Information to be disseminated should be derived from a number of sources including typically early notifications with corrective actions taken or planned, main reports of events and follow-up reports. In addition, other periodic reports issued in the framework of the OEF system (for example, monthly reports, annual reports, topical study reports and summary reports to highlight valuable pieces of operational experience) should also be included.

7.8. Legal requirements and commercial interests within a State could restrict the dissemination procedure, i.e. in matters such as proprietary or confidential information, therefore the regulatory body and the operating organization should make the necessary arrangements with the organizations concerned to ensure that any restrictions on the information to be disseminated are minimized.

7.9. In order to facilitate the dissemination of information, a procedure should be developed at national level. This procedure should:

– define the roles and responsibilities of the organizations involved e.g. operating organization and/or licensee, regulatory body, IAEA/OECD-NEA, WANO;

– define the interfaces between these organizations and the means of reporting (compatibility with international systems and other reporting systems should be achieved during the establishment of this process);

– define the requirements for early notification so that information can be transmitted by the operating organization/licensee to the designated organization for onward transmittal, e.g. regulatory body, utility headquarters;

– define the mutually agreed time for distribution among the recipients of main, follow-up and other types of reports;

– define how to respond to urgent requests for additional information made by any of the interested groups and identify the extent of information to be provided, to discourage excessive additional information request;

7.10. Modern means of disseminating and sharing operational experience, e.g. CD-ROMs, electronic means (local networks, e-mail, Internet) have been found to be particularly convenient. Technical meetings or seminars held on a periodic basis help to consolidate the information exchange.

7.11. A specific means exists for reporting events that may be of interest to the international nuclear community through the IRS [1]. A regular joint review of OEF information that has been issued to IRS should be held on a routine basis (e.g. at least every 6 months). Typically, the review should be carried out by representatives of the regulatory body (when undertaking the role of IRS National Co-ordinator) and the operating organizations. This promotes confidence and understanding between these parties whilst ensuring consistency of reporting nationally, between plants and also internationally. In this respect it would be interesting to compare the actions taken in the various participating countries in response to a given safety significant event. Harmonisation between countries should be striven for.

8. REVIEWING THE EFFECTIVENESS OF THE PROCESS FOR FEEDBACK OF OPERATIONAL EXPERIENCE

8.1. A periodic review of all stages of the OEF process should be undertaken to ensure that all of its elements are performed effectively. Continuous improvement of the OEF process should be an aim/objective of the review. Guidance for such reviews can be found in the Agency's PROSPER Guidelines [6]. An effective OEF process can significantly contribute to minimizing the recurrence of events. In general, there are three approaches to undertaking such a review:

– self-assessment by the nuclear installation;

– peer review to determine whether the process meets established international standards.

– regulatory review/inspection;

SELF-ASSESSMENT

8.2. The operating organization/licensee should periodically review the effectiveness of the OEF process. The purpose of this review is to evaluate the overall process effectiveness and to recommend remedial measures to resolve any weaknesses identified. Indicators of process effectiveness should be developed. These may include the number, severity, recurrence rate of events and causes of different events.

8.3. This self-assessment review should also:

(a) verify that corrective actions arising from the OEF process are being implemented in a timely manner;

(b) consider the continuing need for each of the outstanding corrective actions;

(c) evaluate the effectiveness of solving the original problems and preventing recurrence;

(d) review recurring events to identify whether improvements in the OEF process can be made.

8.4. The operating organization should issue a periodic report, at least annually, which summarizes the activities performed in the interval considered in the framework of the OEF process. Such a report should list the internal and external experience that has been analysed, the corrective actions approved and the status of their implementation. A target completion date should be assigned for those corrective actions still under way.

PEER REVIEW

8.5. The purpose of a peer review is to determine whether the OEF process meets internationally accepted standards and to identify areas for improvement.

8.6. The peer review should:

– review the comprehensiveness of the plant self-assessment and offer comments and recommendations to further enhance the conclusions of the self assessment;

– compare, as far as possible, the OEF process for an operating organization/licensee with guidance and equivalent good practices elsewhere;

– be process performance related so that it is possible to accept different approaches to the implementation of OEF.

8.7. Some of the criteria typically used for assessing the effectiveness of OEF are:

(a) all applicable external experience is analysed,

(b) all internal events are used in the OEF process;

(c) corrective actions are fully implemented in a timely manner;

(d) in the case of internal events, recurrences are minimized and no single root cause dominates the statistics;

(e) the performance of the plant, with respect to events, response to challenges to safety systems and unavailability of safety functions, shows no adverse trend over the period assessed.

9. QUALITY ASSURANCE

9.1. The operating organization/licensee should be responsible for integrating OEF into its quality assurance/management system in accordance with national and international standards. Procedures should be established by the operating organization/licensee for the control of OEF activities at the site to ensure that they are consistent with the objectives of the quality assurance management system. Arrangements should be made to ensure that these procedures are reviewed and approved before issue, and that their subsequent amendment is controlled. Guidance on quality assurance/management system can be found in IAEA publication Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations 50-C/SG-Q [8].

9.2. The OEF system at the plant should be audited by the operating organization/licensee at regular intervals, usually annually, by an experienced group not directly involved in the OEF programme of that plant. This audit team is usually made up of quality assurance staff belonging to the same operating organization. A good practice would involve at least one member from a different plant. The independent audit team acts on behalf of the senior management of the operating organization, to whom the audit conclusions are reported.

9.3. For this to take place, the operating organization should establish a process which is open to scrutiny and defines how every element of the OEF programme is carried out, from

reporting up to the implementation of corrective actions. A complete documentary history of each element of the OEF programme should be maintained, specifying: purpose, scope, procedure, roles and responsibilities, records that should be kept, definitions of terms and references. This suite of documents should be periodically reviewed internally and also be available for any external audit or inspection, e.g. by the regulatory body or WANO.

9.4. Problems or deficiencies noted in the audit report covering the overall administration or function of the OEF programme should be identified and discussed with plant/operating organization senior management. A system or process should be in place to address and resolve these audit findings within the remit of the quality assurance/management system. Any weaknesses identified should be assessed to determine their immediate or potential impact on the overall effectiveness of the programme and corrective action identified for implementation. However, such actions should be introduced in such a way that the OEF process itself continues to function without interruption.

9.5. The regulatory body should include the OEF process as an item for regulatory inspection. The interval for such an inspection should be decided in the context of the overall regulatory inspection programme. In addition to inspecting these elements, the regulatory body should also examine the role of all organizations involved to ensure that information on incidents and abnormal occurrences is communicated effectively to governmental bodies, national and international organizations and others when appropriate(Section 2.6 (12) of [3]).

10. REPORTING OF SAFETY RELATED EVENTS

10.1. The IAEA Requirements for Operation [2] in Section 2.24 states that "All plant personnel shall be required to report all events and shall be encouraged to report on any 'near misses'"[4] and the IAEA Legal Governmental and Infrastructure Requirements [3] in Section 2.6 (12) states that "…the regulatory body shall have the authority to make available, to other governmental bodies, national and international organizations, and to the public, information on incidents and abnormal occurrences, and other information, as appropriate."

[4] A 'near miss' is a potentially significant event that could have occurred as the consequence of a sequence of actual occurrences but did not occur owing to the plant conditions prevailing at the time.

REPORTING PROCESS EXPECTATIONS

10.2. Operating organizations should develop documents outlining appropriate reporting criteria specific to the type of plant being operated and consistent with national regulatory requirements. These criteria should specify the types of events and incidents, including problems, potential problems, non-consequential events, near misses and suggestions for improvement. These reports about events and incidents should be collected and reported internally and some of them should be reported externally to the plant or utility. To promote confidence between the plant(s) and the national regulatory body, documents setting out these criteria should be provided to the regulatory body (and suitably controlled within the scope of the QA system).

10.3. Operating organizations should use a system of coding for reported events. This should facilitate easy evaluation and trending of OEF information.

REPORTING REQUIREMENTS

10.4. Operating experience should be reported in a timely manner in order to facilitate learning from events. To this end operating organizations should have in place, the necessary resources to ensure that events at all levels that occur during operation of the plant are systematically reported and analysed.

10.5. As part of an effective national OEF system, the regulatory body should make clear its expectations for the level at which events are reported to it by the operating organization/licensee. Furthermore, the regulatory body should encourage and support the collection and analysis by the operating organization of data related to low-level events, including near misses, even though such events did not reach the threshold of reporting to the regulatory body.

10.6 For the events to be reported to the regulatory body the following should be established (see also [2] and [3]):

– criteria and categories for identifying information to be reported;

– procedures which ensure that the operating organization reports in a uniform and timely manner; it is vital that all safety significant events be reported;

– channels of communication and assignments of responsibility for reporting.

10.7. The reporting arrangements that enable compliance with national requirements should be clearly specified. These should define the roles and responsibilities of personnel from both the nuclear installation and the responsible national authority.

REPORTING CRITERIA

10.8. Whilst the aim is to encourage reporting of even near miss events, higher levels of the reporting process are only initiated when one or more of the elevated level of reporting criteria are met. The key attributes for reporting criteria of events that should be reported to the regulatory body include the following (Appendix I repeats these in further detail with underpinning information):

(1) A plant shutdown as required by the Operating Limits and Condition (OLC) [7];

(2) An operation or condition prohibited by the OLCs;

(3) Any event or abnormal condition that resulted in the condition of the nuclear power plant, including its principal safety barriers, being seriously degraded;

(4) Any natural phenomenon or other external condition that posed an actual threat to the safety of the nuclear power plant or significantly hampered site personnel in the performance of necessary duties for safe operation;

(5) Any event or abnormal condition that resulted in a manual or automatic operation of the reactor protection system or engineered safety features;

(6) Any event where a single cause or condition caused a significant loss of operability in a safety system;

(7) Liquid or airborne releases of radioactive material to unrestricted areas in excess of previously specified amounts, or exposure of site personnel in excess of authorized limits;

(8) Any event that posed an actual threat to the safety of the plant, or significantly hampered site personnel in the performance of duties necessary for safe operation, including fires, toxic gases, or radioactive releases;

(9) Declaration of an emergency condition as specified in the Emergency Plan;

(10) Any problem or defect in the safety analysis, design, fabrication or operation that results in, or could result in, an operating condition not previously analysed or that could exceed design basis conditions;

(11) Significant safety events during shutdown and refueling, e.g. a dropped fuel assembly;

(12) Any nuclear event that results in death or serious injury to personnel on the site.

REPORTING PROCEDURES

10.9. The operating organization should develop detailed procedures for the reporting of events. Such a procedure should ensure that events with major safety significance are communicated promptly and to the appropriate organizations both internally (at the site) and externally to the utility headquarters, the regulatory body and any other relevant organization.

10.10. The procedure should be such that plant-specific and generic implications of the events reported can be evaluated and appropriate actions identified. The procedure should stipulate a time limit for reporting events, the format for the type of reports and the related administrative arrangements for its distribution and dissemination. Typically, the types of report that should be included in a national OEF system are given in Appendix II.

STORAGE AND RETRIEVABILITY OF OEF INFORMATION

10.11. The IAEA Requirements for Operation [2] state in para. 2.26 that "…data on operating experience shall be collected and retained for use as input for the management of plant ageing, for the evaluation of residual plant life, and for probabilistic safety assessment and periodic safety review."

10.12. Reports in the OEF system should be stored in such a manner that information they contain can be easily sorted and retrieved by both the nuclear installation and the regulatory body, as appropriate. The information, for example, should be arranged to enable frequently needed searches for:

– events at similar units;

– systems or components which failed or were affected;

– identification of the causes of events;

– identification of lessons learned;

– identification of trends or patterns;

– events with similar consequences to the environment or personnel;

– identification of failures types or human factor issues;

– identification of recovery and corrective actions.

10.13. At the plant or operating organization level, a special division or team may be responsible for event data collection, analysis, preparation of reports, storage and dissemination of information related to the events. Source documentation should include extracts from different logs, records of parameters, results of in-service inspections and further testing, or notes by personnel. According to the established practice, the reports are usually stored starting with the construction of the plant. Thus, the complete history of all components and systems can be followed, which allows the analysis of their performance throughout the life of the plant. If the information is also stored in a computerized database, these data can easily provide the basis for assessing the reliability of components and systems. For low-level events, data collection, analysis and storage should be performed by the relevant technical departments.

10.14. Operating organizations should store coded OEF information in company-wide, or (sometimes) national databases to facilitate easy access to, and handling of, data. (See also the Annex). The information should be organized in a recognizable and logical structure and should be readily available to any worker without the need for extensive searching. Web-based systems with hyperlinks to various aspects have been found to be particularly convenient for accessing OEF information.

APPENDIX I: REPORTING CRITERIA AND CATEGORIES

I.1. Whilst the aim is to encourage reporting of even near miss events, higher levels of the reporting process are only initiated when one or more of the elevated level of reporting criteria are met. The key attributes for reporting criteria of events that should be required to be reported to the regulatory body include the following:

(1) *A plant shutdown as required by the Operating Limits and Conditions (OLC)[7]*. For example, if a Limiting Condition for Operation required that the plant change mode from full power operation to another mode, such as hot shutdown or cold shutdown because of unavailability of an essential electrical transformer, then this should be reported pursuant to this criterion.

(2) *An operation or condition prohibited by the OLC.* The OLCs include values for safety limits, limiting safety system settings, limiting conditions for operation, surveillance, design features, and various administrative and organizational requirements if directly connected with plant operations. For example, if a component in a safety system (for example, a pump) was found to be inoperable for more than 7 days, but was allowed by the OLCs to be out of service for a maximum of 7 days during an outage, then this would be reportable as a breach of the OLCs.

(3) *Any event or abnormal condition that resulted in the condition of the nuclear power plant, including its principal safety barriers, being seriously degraded.* This criterion could include conditions where the plant was in an unanalysed condition; a condition outside the design basis; or a condition not covered by the plant's normal or emergency procedures. For example, if a pressurized water reactor (PWR) was in a transition state in terms of temperature and pressure where the pressure-temperature relationship was outside the operating guidance, then this would be reportable. Degradation of the fuel, primary coolant system, or containment would be included as the principal barriers.

(4) *Any natural phenomenon or other external condition that posed an actual threat to the safety of the nuclear power plant or significantly hampered site personnel in the performance of necessary duties for safe operation*. Some examples include earthquakes, fires of an external nature, high winds, tornados, lightning, floods and external threats that might arise from nearby industrial facilities.

(5) *Any event or abnormal condition that resulted in a manual or automatic operation of the reactor protection system or engineered safety features (with some exceptions dependent on the actual circumstances, such as actuation from any part of a pre-planned testing sequence, or when the system was properly removed from service, or if the actuation occurred after the safety function had already been completed.* Use of this criterion by the regulatory body may require the specification of what systems are included as part of the engineered safety systems. Typical systems would include emergency power, emergency core cooling system, auxiliary feedwater, service water, containment cooling and other systems related to accident prevention and mitigation. For example, if there were a failure in an instrument line connected to a reactor coolant system and a resultant leak rate of 300 L/min, then there should be an actuation of a high pressure pump to compensate for this small loss of coolant event. It would be reportable under this criterion.

(6) *Any event where a single cause or condition caused at least one independent train or channel to become inoperable in multiple systems, or two independent trains or channels in a single system to become inoperable for systems designed to shut down the reactor, to remove decay heat, to control the release of radioactive material, or to mitigate the consequences of an accident. This criterion addresses two common-cause concerns which are not necessarily parallel in risk significance or severity.* Events reported under this criterion can include previously unrecognized common-cause (or dependent) failures and system interactions. For example, if a number of pipe snubbers were found to be inoperable such that they would not have been working properly then this could be an instance of generic common-mode problems in several independent trains in multiple systems designed to remove decay heat.

(7) *Liquid or airborne releases of radioactive material to unrestricted areas in excess of previously specified amounts (generally as specified in the (OLCs), or exposure of site personnel in excess of authorized limits.* For example, if a valve in the gaseous waste system was inadvertently opened in such a way that there was a release that was in excess of authorized values off-site, then this would be reportable under this criterion.

(8) *Any event that posed an actual threat to the safety of the nuclear power plant, or significantly hampered site personnel in the performance of duties necessary for safe operation, including fires, toxic gases, or radioactive rele*ases. The actual threat referred

to is from an internal event, as external threats are covered by Criterion (4) above. The intent of this criterion is to ensure the reporting of events that endangered the plant safety or interfered with personnel in the performance of their duties necessary for safe operation. For example, if a fire (or radioactive release) necessitated evacuation of a room for which access was needed to cope with a plant evolution, then it would be reportable under this criterion.

(9) *Declaration of an emergency condition as specified in the Emergency Plan.* In general, the declaration of an emergency condition is communicated to the regulatory body in a manner separate from that described in this Safety Guide. For example, the regulatory body may receive notification of declaration of an emergency by telephone, fax, or by direct communication to a resident inspector. Generally, the condition that caused the emergency declaration would be an event specified in other numbered items in this paragraph, and would result in the generation of an event report.

(10) *Problem or defect in the safety analysis, design, fabrication or operation that results in, or could result in, an operating condition not previously analysed or that could deviate beyond or from design basis conditions.* An example could be the report by a vendor that a particular circuit breaker has a non-revealing fault that could cause binding (such as a lubricant that breaks down with age) with consequent common mode failure actuate on demand. If the nuclear power plant had a number of these breakers in service in various safety systems, then there would be a concern and this criterion would suggest an event report.

(11) *Significant safety events during shutdown and refuelling, such as dropping of a fuel assembly, dropping objects into an open reactor vessel in a fuelled state, loss of boron control during refuelling, or loss of shutdown heat removal systems or loss of water inventory in the reactor vessel.*

(12) *Any nuclear event that results in death or serious injury to personnel on the site.*

APPENDIX II: TYPE OF EVENT REPORTS, TIMING, FORMAT AND CONTENT

II.1. The *preliminary report* (sometimes known as the *early notification report)* should be sent by the operating organization electronically or by telephone or facsimile. These should be followed by a brief written confirmation as appropriate to ensure that adequate information is transferred. Before a detailed written report (hereinafter called "*main report*") is submitted, additional information may be needed for reasons such as:

– further degradation in the level of safety of the plant;

– major changes in the perception of the significance of the event as a result of additional evaluation;

– discovery of new information;

– the need to correct factual errors.

II.2. A *main report* should then be prepared by the operating organization. This report should be submitted to the regulatory body (and possibly other organizations) as soon as practicable. The main report should be marked as *provisional*, if additional information is to be gathered later for evaluation and as *a follow-up report* to finalize the main report, if necessary.

II.3. The operating organization should submit *follow-up reports* whenever the initial report is known to be incomplete or if significant additional information becomes available. The operating organization should also submit specific additional information and assessments as it considers necessary, or if the regulatory body finds it necessary for a complete understanding of an event. When such a request is made, the information and assessments should be provided within an agreed time period. If after the main report is submitted, substantial additional corrective actions are taken or more information from further investigation is available, this should be reported as follow-up information. Reports should, wherever possible, be communicated and disseminated widely and be considered for serving as the basis of material to be exchanged internationally.

II.4. The operating organization should prepare main reports in sufficient detail for persons conversant with the design of the nuclear installation. The report should contain sufficient technical details and whenever appropriate human factor data for an understanding of the

event, without the need for additional information. The standard format and contents of IRS reports [1] may be considered for adoption in national OEF systems, in order to more efficiently link national and international systems.

II.5. The main report should be as comprehensive as possible and be set out in an orderly and consistent manner. The main report should include the following:

- basic information;
- narrative description;
- safety assessment (consequences and implications);
- causes and corrective actions (taken or/and planned);
- lessons learned;
- graphic information to better understand the event(if necessary);
- guide words with their codes.

II.6. *Basic information*. This should include such items as the title of the event, date of occurrence, identification of the plant (name, site), plant type and rated power output, commencement of operation date and an abstract. The abstract should be a brief statement describing the major occurrences during the event, including all actual component or system faults and failures that contributed to it, all relevant personnel actions or violations of procedures and any significant corrective action taken or planned as a result of the event. It should also include how the event was detected, individual injuries, radiation doses received, radioactive material released and information on the classification of the event, which should be compatible and consistent with INES.

II.7. *Narrative description.* The narrative description should explain exactly what happened and what was discovered in the event. Emphasis should be put on how the plant responded and how structures, systems, components, and operating personnel, performed. A description of what the operator saw, did, understood or misunderstood is important, as is how the event was discovered. Unique characteristics of the plant which influenced the event (favourably or unfavourably) should be described. The following specific information should be included: plant status prior to the event, event sequence in chronological order, system and component

faults, operator actions/procedural controls, recurrent events. This should include beneficial or adverse actions, the use of procedures and any procedural deficiencies, and any aspect of the human–machine interface that contributed to the event. This information should help to detect and diagnose safety problems that were triggered by the event.

II.8. The *Safety assessment* should focus on the safety consequences and implications of the event. The primary aim of this review is to ascertain why the event occurred and whether the event would have been more severe, under reasonable and credible alternative conditions, such as different power levels or operating modes. The safety significance of the event should be pointed out.

II.9. *Causes*. The direct, root causes and causal factors of the event should be clearly described. (Annexes A-10 and A-11 of this Safety Guide provide more detail on direct and root causes.) Causes should include reasons for equipment malfunctions, human performance problems, organizational weaknesses, design and manufacturing deficiencies and other facts. Whenever appropriate, the cause analysis methodology used should be referenced in the report.

II.10. Where an event investigation reveals shortfalls in human performance, it is important to specify the inappropriate human actions, i.e. the effects, and also the causes. The aim should be to provide both the technical details of the event and the human performance lessons in ways that can be understood and applied easily to other situations. Human performance is greatly affected by the management systems that are put in place to help workers perform well, e.g. (among other things) planning and scheduling of work, training, supervision, work practices, written instructions and the work environment. When there are latent weaknesses in any of these systems, conditions exist that are likely to lead to error. Information about preceding malfunctions should also be provided. To enable others to learn effectively from experience, event reports should contain clear explanations of what the weaknesses are, how they were detected and the measures taken to remove similar weaknesses.

II.11. All the information concerning persons involved should be de-personalized in order to maintain the privacy of the individuals. If the persons interviewed are made aware of the privacy of their information, the quality of the report will be improved.

II.12. *Corrective actions*. Corrective actions taken or planned upon equipment failures or human errors should be reported. Some corrective actions are more important than others.

Those which are desirable but not essential should be listed as such, or even omitted to avoid overloading an organisation's resources. All corrective actions should be listed and described in sufficient detail, primarily to allow readers to determine their applicability to their plants. It is good practice to include the following aspects:

– Nature of the corrective action (recovery, short term or long term) and any target dates set for implementation;

– Authority taking the action (operating organization);

– Personnel group responsible for implementing the action (operation, maintenance, analysis, etc.);

– For every action, a cross-reference to the identified causes to allow an assessment of the adequacy of the corrective action.

II.13. *Lessons learned*. The report should clearly identify learning points. The communication of lessons learned should result in enhanced safety, positive changes in working practices, increased reliability of equipment, and improvements in the procedure. The sharing of operational experience lessons learned is one of the most valuable parts of the feedback process.

II.14 *Graphic information to better understand the event.* The report should provide support information, if necessary, such as diagrams, data printout, plots of main equipment parameter changes; protocols and check lists of equipment tests performed after the event; operational data of damaged or failed equipment.

APPENDIX III: INVESTIGATION AND ANALYIS OF EVENTS

INVESTIGATION OF EVENTS

III.1. The management level to which the investigator(s) reports should depend on the degree of severity (or potential severity) and the frequency of occurrence of the event. It is just as important to investigate minor events that occur frequently, as it is to investigate one-off events with serious consequences, bearing in mind that all events have the potential to be more serious.

III.2. The number of investigators and their areas of expertise should be based on the type of plant and characteristics of the event. Appropriate experts in reactor systems, human factors, operations and mechanical, electrical, or instrumentation and control systems specialists may be needed. Additional members could include specialists in physics, plant behaviour, radiological assessment, health physics, chemistry, materials, emergency preparedness, or other specialized areas.

III.3. Training (both initial and refresher) should be provided for the staff who might take part in an investigation. This should include investigation techniques, documentation needs, witness interviews, conflict resolution, and dealing with confidentiality issues. Event investigation training for personnel from operating organizations is frequently available from internal corporate departments, the supporting organizations, the World Association of Nuclear Operators (WANO) and the Institute of Nuclear Power Operations (INPO), as well as through the IAEA. Whereas all investigators should have received some basic training in event investigation including root cause analysis, for the more difficult and complex investigations, there may be the need for at least one expert facilitator familiar with such methods of investigation.

III.4. There should be a mandate established for the investigation activities. This should set out the format and terms of reference and should typically cover the following areas:

- Conditions preceding the event;
- Sequence of events;
- Equipment performance and system response;

– Human performance considerations;

– Equipment failures;

– Precursors to the event;

– Plant response and follow-up;

– Radiological considerations;

– Regulatory process considerations;

– Safety significance.

III.5. The mandate should include a review of the design and licensing basis for the facility as necessary as part of the assessment of the cause for the event under investigation or to identify a plant response beyond the licensing basis.

III.6. The investigator (or lead investigator, if there is more than one person involved in the investigation) should be competent in investigation skills as well as having technical, administrative and managerial competencies.

III.7. The on-site investigation should start as soon as practicable to ensure that information is not lost or diminished or that evidence is not removed. It is vital that the on-site investigation does not inhibit operational staff from bringing the plant to a stable state.

III.8. Interviews should be conducted with all the staff involved, or witness to the event. Interviews should be transcribed. A sequence of events, e.g. an Event and Causal Factors Chart, should be started immediately and continuously updated as new data are gained.

III.9. Investigators should prepare a written report and present it to the management group that commissioned the investigation. In some cases there will be a request for corrective actions commensurate with the identified root causes.

III.10. The investigation should include:

– Preparation of status reports and other interim reports documenting significant activities, findings, and concerns.

– Ensuring that safety at the incident scene is maintained as appropriate.

– Ensuring that the investigative activities do not result in any adverse impact on the rest of the plant.

– Keeping plant management advised of the status, progress, and future plans related to the investigation.

– Initiating requests for information, interviews with witnesses, laboratory tests, and technical or administrative support.

– Maintaining control of information and material collected as part of any investigation.

III.11. It is not the object of the investigation to assign blame or fault, or to recommend or dispense disciplinary actions. Conducting investigations in such an environment is not conducive to establishing the facts that will lead to the identification of root causes and hence the corrective actions to improve safety, and equipment and human performance.

ANALYSIS OF EVENTS

III.12. In most instances the first step and basis for further evaluation in event analysis is the establishment of the event sequence. This means the listing in chronological order of all relevant occurrences or activities leading to and subsequent to the event.

III. 13. Based on the event sequence it should be possible to determine all deviations from the expected state. Thus the occurrences and activities that have to be analysed in depth can be identified. Different areas have to be considered in the analysis such as design, organization, procedures, human actions, component faults, and material behaviour. In some cases, the inclusion of additional expertise in the cause analysis should be considered. Very often the notions of immediate (direct, observed) causes, root causes and contributing factors are used in the cause analysis. Cause identification should be carried out for the formulation of corrective actions. The depth of the causal analysis should be adequate to ensure the identification of appropriate corrective actions.

III.14. Numerous root cause methodologies, many having a similar basis, have been developed or are under development to address the connection between root causes and corrective actions (See Annex). Since there is not one best technique to use for all events in all States, the evaluator should select the most appropriate tool for the event in question, in the context of the national capabilities.

III.15. The analysis of events related to human characteristics should contain the causes and circumstances of human performance problems that contributed to the event. The human errors that affected the course of the event may include either errors of commission or errors of omission. There may also be procedural deficiencies, and there may be a combination of human errors and procedural deficiencies. Errors and human performance related issues may be in the areas of procedures, training, communication, human engineering, management and supervision. The analysis should be sufficient to categorize the human performance issues (The Annex covers the treatment of human errors in event analysis in more detail).

III.16. The analysis should consider and identify:

- whether human errors were either cognitive (such as failure to recognize the actual plant condition, failure to realize which systems should be functioning, failure to recognize the true nature of the event), or else was there an error in the following of procedures;

- whether human deficiencies in the use of procedures were characterized by difficulty either in terms of failure to follow an approved procedure, or the use of a procedure that contained erroneous instructions, or was associated with an activity or task that was not covered by an adequate procedure;

- whether any unusual characteristic of the work location, such as heat, humidity, noise, radioactivity, accessibility or signage contributed to the human performance problem;

- whether there were any ergonomic or human engineering issues;

- the type of personnel involved (such as licensed operator, unlicensed operator, supervision and management staff, contractor personnel, etc.).

APPENDIX IV: APPROVAL AND IMPLEMENTATION OF CORRECTIVE ACTIONS

IV.1. Prior to implementation, the recommended corrective actions should be reviewed and approved at the appropriate level. The approval process depends on the significance of the corrective actions and on the national practice. An administrative verification should ensure that the requirements for the approval process itself have been met and that the proper documentation and forms have been completed. Documents that are typically submitted for approval may consist of:

- a detailed description of proposed corrective actions (including drawings, schematics, process or flow charts etc.);
- a safety review which assures that the proposed corrective actions improve safety and have no adverse effects;
- quality plans which assure compliance with design standards;
- plans and schedules for implementing the corrective actions, responsible persons and terms of implementation;
- procedures for undertaking a safe working method;
- organizational and human performance considerations.

IV.2. The corrective actions should then be discussed with and accepted by the organizations or individuals who are to be made responsible for their implementation. There are at least three levels of approval (plant management [on-site], operating organization and regulatory authority). The information on corrective actions should be incorporated into the personnel training programme as soon as possible.

IV.3. Factors to consider during the formulation of corrective actions should include:

- whether the corrective action addresses the fundamental problem;
- what adverse consequences may result from its implementation;

– whether the corrective action is compatible with other corrective actions previously implemented;

– whether the corrective action has been tried before, and with what results;

– whether the corrective action is an interim or final solution;

– for plants which use risk assessment techniques in corrective actions, a risk improvement factor should be considered;

– an assessment of the corrective action schedule should be made, taking into account the base level of risk, and the incremental improvement that is attributed to the corrective action;.

IV.4 The corrective action plan should include a provision for verification of effectiveness of the action.

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ANNEX 1: OEF DATA MANAGEMENT

LOW LEVEL EVENTS

A-1. For the purposes of this Safety Guide, a low level event (which includes the near miss) is the discovery of a weakness or a deficiency that would have caused an undesirable effect but did not, due to the existence of one (or more) defence in depth barriers [5]. (Instead, there would be minimal or no consequences for a low level event.) Low level operational events are those reported within the plant or operating organization as anomalies, conditions or situations which are usually screened out during the process of handling safety significant events (as, for example, findings during testing, in-service inspection, or surveillance). They form the majority amongst the reported events within the plant. Individually they appear to be unimportant. However, when aggregated to other low level events, they can reveal features of common patterns, trends and recurrence information which may be significant for further enhancing plant safety.

A-2. Owing to the large number of low level events and to the difficulties identifying the useful parts of such information, it is generally accepted that low level events should be treated by the operating organization, perhaps with the aid of computerized systems (databases) which can effectively sort and manage the large quantities of data accumulated.

A-3. Evaluation and in-depth analysis of operating experience should not be restricted only to lessons learned from safety significant events but also from situations and events of lower importance which would have had the potential to evolve into safety significant events, but were prevented by plant design and/or corrective operator actions.

OEF INFORMATION MANAGEMENT

A-4. Retrieval and evaluation of information can be facilitated by using a coding scheme (e.g. the IRS or WANO coding systems) and arranging the storage system to contain records of each component, system fault or personnel action involved in a reported event. Different techniques are used for storage, tracking and documentation of national event reports, from simple storage of hard copies to computerized full text databases using guide words and codes for quick search and retrieval of information.

A-5. Consideration should be given to developing a standard data input sheet for gathering information from the narrative report in order to facilitate computerized storage and retrieval.

The computerized system should be capable of searches for key words (single key words, a combination of key words and limited field searches) and should also be capable of full text searches. Computerized information management should be utilized when the amount of information justifies it. Such a system should ideally be adapted to enable finely structured searches to be made for information needed to support in-depth safety investigations, or to detect trends and generic aspects.

A-6. A computerized system for the preparation, storage, dissemination, searching and retrieval of OEF system information can:

– increase the effectiveness of nuclear safety experts in analysing and communicating operational safety experience;

– facilitate the process of preparation, storage and dissemination of OEF information;

– promote the most advanced methods for dealing with the information.

A-7. Linkage of the OEF database together with other application programmes such as technical information on plant design and construction, plant reliability databases, performance indicators, and other analytical programmes can enhance overall nuclear safety.

A-8. An OEF programme should achieve the following objectives:

(1) the collection of information is sufficiently comprehensive that no relevant data are lost (this necessitates broad reporting criteria and low detection thresholds);

(2) the information collected is screened efficiently so as to ensure that all important safety related issues, which ought to be analysed with priority, will actually be selected (this necessitates clear ranking criteria);

(3) the issues selected are analysed in sufficient depth to permit the identification of the underlying root causes in the design, the surveillance activities carried out on equipment, personnel qualification and personnel aids;

(4) the relevant corrective actions are implemented promptly enough to prevent the recurrence of similar events that could be affected by the same category of underlying root causes;

(5) the lessons learned are disseminated promptly enough to enable other utilities to take corrective actions before further similar events occur.

TOOLS FOR CAUSAL ANALYSIS

A-9. For the purposes of causal analysis, the following definitions should be useful:

A-10. The **immediate cause**, sometimes known as the direct or observed cause, is the occurrence (or occurrences) which breach or violate certain authorized or prescribed processes and conditions at the plant. Repair or correction of the identified direct cause is of primary importance in dealing with plant safety, and perhaps restart[5] of the plant.

A-11. The **root cause** or causes should provide the explanation as to why the immediate cause took place. The root cause should lead to the corrective actions, as remediation of the root cause should prevent recurrence. The root cause is the most basic cause or causes of an event that can be reasonably identified, and is directly correctable.

To be considered a root cause, the cause need meet only one of the following:

- the problem can be duplicated;
- the problem would not have occurred had the causes not been present,
- the problem will not recur due to the same cause if the cause is corrected.

A-12. Depending on the nature of the event, there may be an additional tool for the safety assessment of the event. This tool, known as precursor analysis, uses a probabilistic approach. Usually the probabilistic approach is applied for precursor studies in event analysis domain, but events can also be analysed with the same objectives as for a probabilistic approach itself.

A-13. The precursor methodology, known in several States as either Accident Sequence Precursor (ASP) methodology or PSA Event Analysis, is able to develop what is known as a Conditional Core Damage Probability (CCDP). This sort of analysis produces a quantitative assessment of the likelihood of core damage, if additional failures or errors had been present. A precursor to potential severe core damage is an event or condition that could have been serious if plant conditions, personnel action, or the extent of equipment failure or faulting had

[5]At times, authorization for plant restart is granted by the regulatory body before the full range of root causes is determined.

been slightly different than that which had occurred. Because of the relatively small number of events that might warrant exploration by the precursor methodology, it might not prove practical for States with a small number of nuclear power plants.

A-14 The traditional ways of investigating events at nuclear installations have been predominantly qualitative. Recently however, a PSA-based method called Probabilistic Precursor Event Analysis is being used more frequently as it allows also for a quantitative estimation of the safety significance of events. This method uses the concept of Conditional Core Damage Probability as a measure of the safety significance and it can be applied to improve the reliability of selection of events for in-depth analysis as well as in the process of selecting and prioritising corrective and preventive actions. [10]

A-15. Based on practical investigations, several analytical techniques have been developed, tested, and implemented in order to direct the investigation process. All of the available techniques serve three purposes:

- to organize event information once the evidence has been collected;
- to help in describing event causation and developing hypotheses for future examination by experts;
- to help with the assessment of proposed corrective actions.

A-16. Such techniques can support an investigation and help focus on the important features of the event causation. Several, if not all, of the available techniques can provide useful frameworks for displaying and documenting the cause-consequence relationships. They can also be used to develop visual aids to better communicate the lessons learned.

TREATMENT OF HUMAN ERRORS IN EVENT ANALYSIS

A-17. In order to understand operational events with human factor characteristics, it is necessary to understand the causes of human errors. This necessitates a knowledge of the mechanisms of human activity, i.e. a knowledge of basic human behaviour under certain circumstances and in a certain context. Human errors can seldom be attributed to one cause. Many influences in the environment have a direct or indirect influence on an individual.

A-18. Human factor specialists should participate in the event investigation and in the evaluation of the contributing personal, group and organizational deficiencies. They may provide a valuable contribution to the analysis owing to their specific knowledge about human behaviour.

A-19. Since the treatment of human dimension in event analysis issues needs a knowledge of the context that the individuals perceive during their activities, the collection of information on human characteristics and the corresponding analysis should be started at the plant level. As stated in paragraph A-1 of this Safety Guide, low level events, which include near misses, involving human factor considerations should be reported to the operating organization, by whom details should be maintained, even if the events do not reach the threshold of reporting to the regulatory body.

A-20. The purpose of an analysis of the human factor aspect of an event is not to delve deeply into the psychological details of individuals, but rather, to take into account and to use the established knowledge about basic human behaviour in order to understand the contributing and influencing factors which have led or may have disposed the person to make an error, either of omission or commission.

A-21. Different models on human performance exist which can be easily understood by interested people without specific training in social sciences. Use of these models can contribute much to the diagnosis of human performance during a reportable event.

ANNEX 2: EXAMPLE OF ELEMENTS OF A NATIONAL OPERATING EXPERIENCE

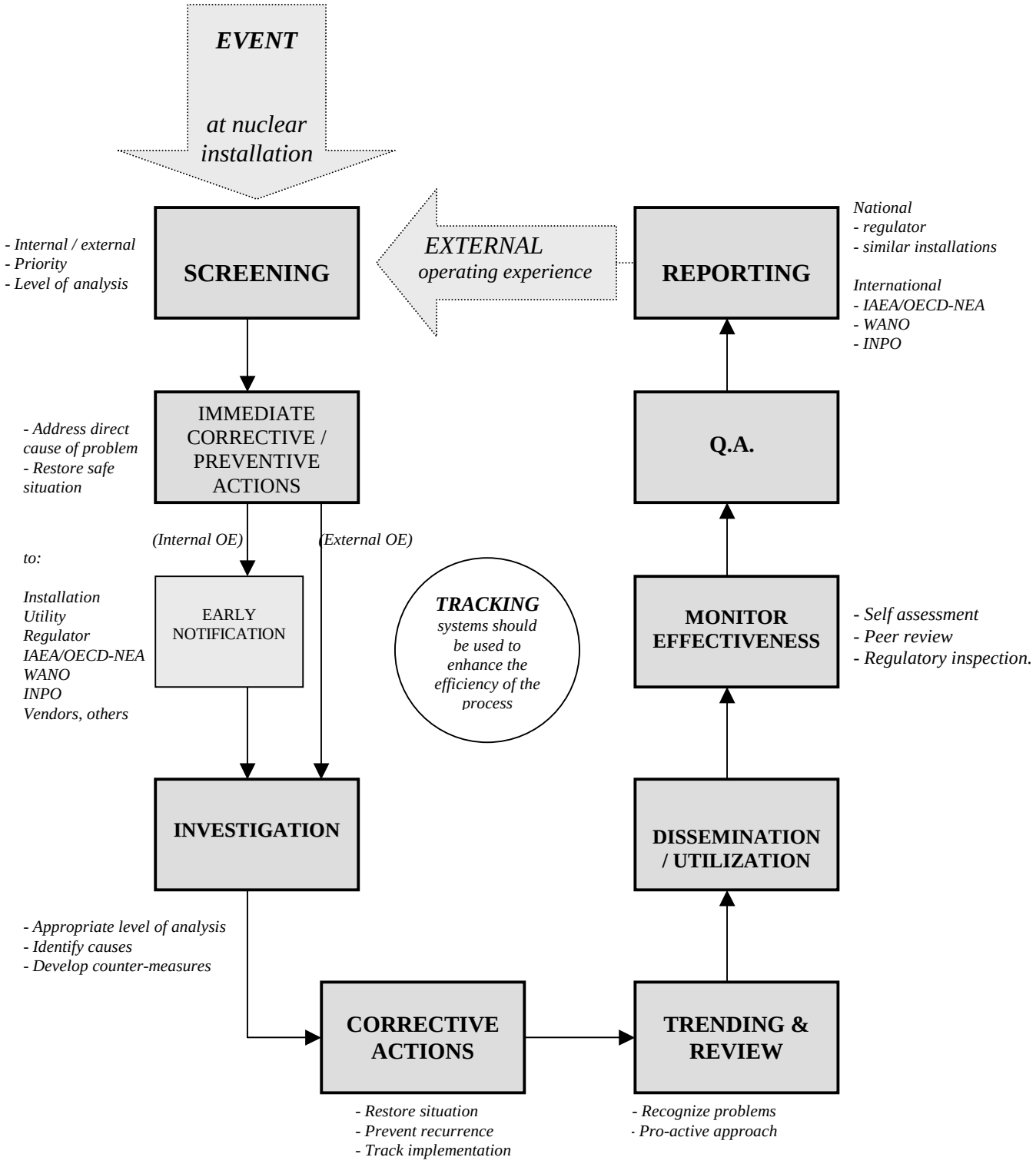

Figure 2-1. Example of elements of a national operating experience feedback (OEF) system

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